PART I - ADMINISTRATIVE

Section 1. General administrative information

Title of project	
Test guidance flows and strobe lights at a SBC to increase smolt FCE & FGE	
BPA project number	**20122**
Contract renewal date (mm/yyyy)	
Multiple actions? (indicate Yes or No)	
Business name of agency, institution or organization requesting funding	
Washington State Department of Fish and Wildlife	
Business acronym (if appropriate)	**WDFW**
Proposal contact person or principal investigator:	
Name	**Charles Morrill, WDFW, Fish Program**
Mailing address	**600 Capital Way North**
City, ST Zip	**Olympia, WA 98501-1091**
Phone	**360 902-2747**
Fax	**360 902-2183**
Email address	**cfwdfw@aol.com**
NPPC Program Measure Number(s) which this project addresses	
5.6A.13. ...Explore promising new approaches to fish bypass technologies....	
FWS/NMFS Biological Opinion Number(s) which this project addresses	
Action Number .....Immediate Measure 15. And 15.3.	
Other planning document references	
Action #... 2.3.b., 2.3.b.10., 2.3.d.1 in NMFS Proposed Recovery Plan (March 1995) **Action #... Page 5B-41 in CRITFC Wy-Kan-Ush-Mi Wa-Kish Wit (Spirit of the Salmon) (June 1995)** **Actions #... Subchapter 3: Hydropower/Dams in Chapter 14 of Washington State's Draft Lower Columbia River Draft Conservation Initiative (March 10, 1998)**	
Short description	
Test guidance flow and strobe lights at the Cowlitz Falls Dam to increase FCE and FGE. Radio telemetry, fyke and flume nets and facility collection will be used to measure the success of guidance flow and strobe lights.	
Target species	
Steelhead, coho and spring chinook smolts	

Section 2. Sorting and evaluation

Subbasin
Cowlitz Basin above Cowlitz Falls Dam located at RM 88.5.

Evaluation Process Sort

CBFWA caucus		CBFWA eval. process		ISRP project type	
X one or more caucus		If your project fits either of these processes, X one or both		X one or more categories	
X	Anadromous fish		Multi-year (milestone-based evaluation)		Watershed councils/model watersheds
	Resident Fish		Watershed project eval.		Information dissemination
	Wildlife				Operation & maintenance
					New construction
				X	Research & monitoring
					Implementation & mgmt
					Wildlife habitat acquisitions

Section 3. Relationships to other Bonneville projects

Umbrella / sub-proposal relationships. List umbrella project first.

Project #	Project title/description

Other dependent or critically-related projects

Currently, Bonneville Power Administration funds The Cowlitz Falls Project - Anadromous Fish Reintroduction Program. Although not under the Fish and Wildlife Program, it is listed here because this proposal builds on the monitoring and evaluation program currently underway at the Cowlitz Falls Dam.

Project #	Project title/description	Nature of relationship
DE-MS79-91BP93212	Cowlitz Falls Project Anadromous Fish Reintroduction Program DE-MS79-91BP93212	Funded under Power Generation Division of BPA

Section 4. Objectives, tasks and schedules

Past accomplishments

Year	Accomplishment	Met biological objectives?

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Test and measure the effectiveness of guidance flows and strobe lights at the Cowlitz Falls hydroproject to increase FCE and FGE.	a	Review estimates of Fish Guidance Efficiencies obtained in 1998 and 1999 as baseline for study objectives.
		b	Use radio telemetry data obtained in 1998 and 1999 for salmonid smolt approach, passage and FGE to refine and finalize study design.
		c	Monitor approach/passage and collection of radio tagged juvenile salmonids with directed flow and strobe lights on/off.
		d	Test and measure the effectiveness of guidance flows in increasing FCE and FGE; monitor and enumerate smolt catch in SBC collection flumes throughout on/off test blocks.
		e	Test the effectiveness of strobe lights in reducing passage through the induction slots; measure the proportion of radio tagged fish passing the induction slots with the lights on compared with the proportion passing the induction slot with the lights are off.
2	Determine how environmental conditions effect guidance flows and/or strobe light guidance; ie diel patterns, turbidity, and flow.	a	Measure reservoir turbidity and correlate to strobe light effectiveness
		b	Monitor day vs night responses using data from task #'s 1c,1d and 1e.
3	Complete reports and identify effective ways to utilize this technology to enhance FGE at other hydroprojects throughout the	a	Complete compilation and analysis of all data collected for the application of guidance flows and strobe lights to enhance FGE in a Project completion

Obj 1,2,3	Objective	Task a,b,c	Task
	Columbia Basin.		report.
		b	Present results at workshops and/or seminars related to fish passage/collection in the basin.
		c	Host workshops/tours on site to demonstrate application of technology.
		d	If successful complete proposal for fy2001 to use guidance flows and strobe lights to increase guidance and collection efficiency in the near zone in front of the project.

Objective schedules and costs

Obj #	Start date mm/yyyy	End date mm/yyyy	Measureable biological objective(s)	Milestone	FY2000 Cost %
1	10/99	9/2000	Test and measure the effectiveness of guidance flows and strobe lights at the Cowlitz Falls hydroproject to increase FCE and FGE.		70%
2	10/99	9/2000	Determine how environmental conditions effect guidance flows and/or strobe light guidance; ie diel patterns, turbidity, and flow		10%
3	7/2000	3/2001	Complete reports and identify effective ways to utilize this technology to enhance FCE and FGE at other hydro-projects throughout the Columbia Basin.	12/2000 - draft	20%
				Total	

Schedule constraints

The Cowlitz Falls Dam is a run of the river hydro-project and high flows may require the project to lower the reservoir, rendering the fish collection facility inoperable. However, recent discharge records indicate that it is unlikely flows would be high enough to require a drawdown durring the study period. It is possible that project operation and/or maintenance may require a schedule change.

Completion date
October 31, 2000

Section 5. Budget

FY99 project budget (BPA obligated):	$

FY2000 budget by line item

Item	**Note**	**% of total**	**FY2000 ($)**
Personnel	WDFW: temp. fte's for on-site field work and supervision USGS: telemetry components	19%	$19,000 $38,000
Fringe benefits	WDFW USGS	6%	$5,300 $13,000
Supplies, materials, non-expendable property	WDFW - guidance flow USGS - radio tags	36%	$25,000 $80,000
Operations & maintenance	USGS - vehicles	1%	$2,000
Capital acquisitions or improvements (e.g. land, buildings, major equip.)	Strobe lights -	20%	$60,000
NEPA costs			$0
Construction-related support			$0
PIT tags	# of tags: 0		$0
Travel	USGS - telemetry	2%	$5,000
Indirect costs	WDFW USGS - telemetry	16%	$26,000 $22,000
Subcontractor			$0
Other			$0
		TOTAL BPA REQUESTED BUDGET	$295,300

Cost sharing

Tacoma Public Utilities (TPU) has supported components of the Cowlitz Falls Program since its inception and has expressed support for the project. TPU is currently engaged in the FERC relicensing process for its projects below Cowlitz Falls and a detailed review and discussion of alternatives for the Cowlitz basin. An Ecosystem Diagnostics Treatment (EDT) of the basin recognizes the Cowlitz Falls reintroduction program as an important component of future plans for the basin as well as the importance of improving fish collection and guidance efficiency (FCE and FGE). WDFW and others are working with TPU and seeking their participation and financial support for the project.

Lewis County PUD with funds provided by BPA, maintains the facility, and operates the projects heavy equipment used to set up and conduct components of the studies, as well as staff time involved with study coordination and implementation.

Organization	Item or service provided	% total project cost (incl. BPA)	Amount ($)
TPU	To be determined		
Total project cost (including BPA portion)			

Outyear costs

	FY2001	FY02	FY03	FY04
Total budget				

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Watershed?	Reference
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PART II - NARRATIVE

Section 7. Abstract

We propose to test and measure the efficacy of guidance flows and strobe lights to increase Fish Collection Efficiency (FCE) and Fish Guidance Efficiency(FGE) for steelhead, coho, and spring chinook smolts at the Surface Bypass Collection system at the Cowlitz Falls Dam. We will test the hypotheses that 1) guidance flows will increase guidance and collection efficiencies, 2) that strobe lights will deter passage through the induction slots and coupled with guidance flows, increase FCE and FGE. Past and current research clearly show that strobe lights can be an effective behavioral guidance tool. Coutant (1998) suggests that the addition of directed flows may provide smolts cues that would enhance guidance and acceptance of SBC pathways. The combination of guidance flows and strobe lights offers a potential tool to enhance FCE and FGE for migrant juvenile salmonids. Radio tagging, flume netting, and SBC collection in the fish facility will provide the tools to measure the response and behavior of the juvenile salmonids to guidance flows and strobe lights. The experimental study design will utilize on/off blocks of time throughout the primary migration periods for each species. The results could serve as a model for enhancing FCE and FGE of other bypass and SBC systems in operation in the Columbia Basin and may offer managers an efficient and cost effective tool.

Section 8. Project description

a. Technical and/or scientific background:

8.a.1. Surface bypasses offer much promise for passing downstream-migrating juvenile salmonids past hydropower dams without going through turbines. Turbine passage has been documented in several studies to cause significant mortality due to pressure changes, shear and mechanical damage from turbine blades and their housing. The successful "hydrocombine" design at the Wells Dam on the Mid-Columbia River has stimulated high-priority testing and evaluation of similar designs at other facilities (e.g., Corps of Engineers at Lower Granite Dam on the lower Snake River) (Whitney et al. 1997). This configuration at Wells effectively creates an attraction flow field with a relatively large amount of water near the surface of the forebay immediately upstream of the dam, which the salmonid smolts sense and follow through to the bypass. A common difficulty in testing surface bypass prototypes at other projects throughout

the basin has been the inability of fish in the dam forebay to detect and enter the bypass entrance.

8.a.2. The Cowlitz Falls Hydroelectric Project began operation in the spring of 1994 and is modeled after the Wells Hydroelectric Project. A "state of the art" surface collector and facility which includes attraction, collection, dewatering, bypass, and handling/transport facilities was completed in 1996. Results to date at the Cowlitz Falls project with two full seasons of operation and collection, using mark recaptures, hydro-accoustics, radio telemetry with steelhead, and snapshots of flow and fish directional vectors using ACDP in the forebay clearly demonstrate that many salmonid smolts do not readily find their way to the collection system and pass the project though the turbines via the induction slot or directly through the turbine intake.

8.a.3. We have marked and recaptured groups of steelhead, coho and spring chinook collected at the facility over the last three seasons to estimate of collection efficiencies. The recapture data suggests that at best collection efficiencies for steelhead approach 75 percent, but average about 50 percent and are less for both coho and spring chinook. However, the results from fyke netting the turbine intake slot in 1998 show that collection efficiencies for steelhead and coho are related to flows. At flows less than 6500 cfs collection efficiencies typically exceeded ninety percent for steelhead smolts and eighty percent for coho smolts. Only two tests were conducted at flows greater than 6,500 cfs. At 10,500 cfs collection efficiencies dropped to ten percent or less. With flows less than 3000 cfs collection efficiencies for summer migrant age zero spring chinook smolts ranged between twenty and forty percent. The fyke net frame was designed to fish both the turbine intake and turbine induction slots, yet no smolts were captured in the nets suspended in the induction slot. However, thirty-one percent of the radio tagged steelhead detected passing the project (entering the collection facility or passing the project via the turbine intake or induction slot) went through the induction slot.

8.a.4. Staff from the United States Geological Survey (USGS), Biological Resources Division (BRD), Columbia River Research Laboratory in Cook Washington in cooperation with Public Utilities District No.1 of Lewis County, Cowlitz Falls Project and WDFW conducted a pilot study with steelhead smolts in1998 to help us understand the behavior of juvenile salmonids as they approach and pass the Cowlitz Falls Dam and its surface collection system (Rondorf,et.al. 1998).

In addition, USGS staff used split beam hydro-acoustics and an Acoustic Doppler Current Profiler to provide a snap shot of smolt distribution, relative directional vectors for fish movement in the forebay, water velocities and vectors in the forebay of the dam at three test flows. A total of fifty-two steelhead smolts were released with radio tags 9 km upstream of the project and their movement, approach and passage routes through the project or into the collection facility were monitored. Forty-six (46) tagged steelhead were detected in the forebay, within three hundred meters of the dam. Seventeen (37 %) of these fish detected in the forebay went back upstream and were not detected in the forebay again before the battery expired. Thirteen fish (28 %) entered the forebay, went though the entrance slot in the baffle panel and then went back out into the forebay. Of these, four went back upstream and were not detected again, seven went back through the baffle slot and on into the collection system, one went back through the baffle slot and into the turbine via the induction slot and one fish went through the turbine via the turbine intake. All total, twenty-nine tagged fish (63 %) were detected passing the project and/or entering the collection facility. Sixteen of these twenty-nine (55 %) entered the collection system. Thirteen of the twenty nine (45 %) passed the project via the induction slot or turbine intake and nine of these (31 %) went through the induction slot. These nine fish that went through the induction slot represent nearly twenty percent of the tagged fish detected in the forebay. A one

day snap shot of fish directional vectors in the forebay with an ACDP indicated a general movement of fish away from the project. Thus its clear to us that we need to provide effective cues for fish to find and enter the collection system and deter fish from passing through the turbine intakes and turbine induction slots.

8.a.5. The application and testing of guidance flows coupled with strobe lights to deter fish passage through the induction slots offers what may be an effective tool to improve fish guidance and collection efficiency. Guidance flows would provide cues to attract and guide fish from the near zone in the forebay on through the slots in the baffle panels and on into the collection flumes (Coutant, 1998). Strobe lights placed in the entrance to the induction slots would deter smolts from entering and divert them away from the induction slot and provide them the opportunity to discover and cue in on the guidance flows to the collection flumes. One form of directed guidance flow in a forebay has been successful in guiding Atlantic salmon to a fish bypass in New England in preliminary tests (Truebe and Truebe, in press).

8.a.6. Fish diverted from entering the turbine induction slots by a strobe-light system still may not have sufficient hydraulic cues to orient to the surface bypass entrances, which are small relative to the entire dam forebay. Coutant (1998) summarized the natural ability of migrating salmonids to recognize higher velocities in turbulent river water and to orient downstream with typical riverine hydraulic features such as turbulent eddies. Non-turbulent flow fields ("flownets" of Johnson et al., 1997) based solely on differences in hydraulic head between the forebay and bypass portal do not supply sufficient cues to attract migrants except close to the entrance (Rainey, 1997; Rainey, 1997b). Numerous surface bypass prototypes based on attraction by non-turbulent hydraulic head differences have failed to yield desired high guidance efficiencies (e.g., Stockley, 1959; Wayne, 1961; Johnson et al., 1997; Pevan et al., 1996). Coutant 1998 hypothesized that a "trail of turbulence" in the quiescent surface waters of the forebay would enlarge the "opportunity for discovery" of the bypass entrance and minimize migration delay.. We propose to test an array of pumps or jets to create a "trail of turbulence" in the forebay and from the baffle slot to the entrance to the surface bypass collection flume.

8.a.7. Strobe lighting as a behavioral guidance tool for fish has been tested for over forty years in laboratories, modified field tests, and in full site applications. Many early efforts to evaluate strobe lighting were encouraging. Other laboratory or field tests may have been adversely impacted by the limited capabilities of the equipment utilized. Testing prior to late 1991 utilized strobe lighting equipment purchased "off the retail shelf". These systems were primarily designed for above water usage. Over the past seven years Flash Technology Corporation of America (FTCA) has been actively involved in developing systems specifically designed for prolonged and effective usage underwater and application to fish guidance needs. Systems that are multi-functional, highly flexible, remotely controlled and that allow for real-time response to site-specific variables are now available through FTCA. In 1987-88 research conducted at the University of Washington's School of Fisheries, juvenile Atlantic salmon, coho, chinook and steelhead showed a consistent avoidance of the strobe lights and did not acclimate to the strobe lighting (Nemeth, 1989; Nemeth et al., 1992).

8.a.8. Currently several projects using strobe lights as a fish guidance behavioral tool are underway in the region. The Seattle District of the Corps of Engineers has completed testing strobe lights at its Hiram M. Chittenden Locks facility and will install strobe lights in 1999 to deter juvenile salmonids from entering filling culverts in the lock facility. Testing at the Hiram M. Chittenden Locks facility over the past two years demonstrated that strobe lights elicited consistent displacement of juvenile salmonids both vertically and horizontally (Johnson et al,

1998; Ploskey et al, 1998). Based on tests in which kokanee salmon were repelled more than one-hundred feet from a strobe light system, the Idaho Department of Fish & Game firmly believes that strobe lighting would be an effective behavioral barrier to prevent the entrainment of kokanee at Dworshak Dam during periods of spill and drawdowns and continue to test and seek funding to install a strobe lights system (Maiolie, pers. comm.). On the Columbia River near Burbank, WDFW and BOR completed successful tests using strobe lights to prevent salmonid smolts from entering an irrigation diversion canal in 1998 (Easterbrooks, pers. comm.). In the spring of 1998, the WDFW tested the response of wild chinook salmon smolts at Roza Dam to strobe lights, finding that the smolts were repelled up to 20 feet in the cage during the tests with strobe lights at night (Amaral et al., 1998). Great Northern Paper and FTCA are entering the fourth year of a five year agreement to test strobe lights to improve guidance of Atlantic Salmon smolts towards the surface bypass routes at Weldon Dam on the Penobscot River in Maine. In the tests conducted to date strobe lights have reduced passage of radio tagged smolts through the targeted turbines by fifty percent (Bernier, 1998).

8.a.9. The Cowlitz Falls Dam is an excellent candidate site to demonstrate the use of strobe lighting and guidance flows as behavioral guidance tools to increase FCE and FGE of the SBC due two turbine configuration allowint side by side, on off testing with minimal confounding variables. Also the low velocity at the dam face and expected turbidity levels during the spring migration which will allow the juveniles adequate time and distance to respond to the strobe lights.

b. Rationale and significance to Regional Programs

8.b.0. In October, 1998 the US Army Corps of Engineers' Waterways Experiment Station Fisheries Engineering Team formally recommended that strobe lighting be used as a behavioral technology enhancement to increase the FGE of surface bypass collectors, based on the results of two seasons of testing strobe lighting at the Hiram M. Chittenden Locks in Seattle. Application of strobe lights and guidance flow to improve effectiveness of surface bypass collectors would be a low cost and low impact sollution.

8.b.1. The Cowlitz Falls Project, Anadromous Fish Reintroduction Program was initiated by BPA in 1992. This program developed from an agreement between BPA and Friends of the Cowlitz as a result of the Power Purchase Agreement with Lewis County PUD. The program calls for the reintroduction of spring chinook, coho and late winter steelhead. Searun cutthroat were added to the plan due to their presence at the fish collection facility. The program reopens approximately 200 miles of previously productive river and tributary habitat to these anadromous species. This program is consistent with the State of Washington's Wild Salmonid Policy (WDFW, 1997) and the "Lower Columbia Steelhead Conservation Initiative" (WDFW, draft, 1998). The LCSCI is being prepared to comply with the action taken by NMFS in March 1998 listing steelhead in the Lower Columbia River (62 FR 43974) in accordance with NMFS guidelines(NMFS, 1996c). It is also directly applicable to the regional programs in the Columbia Basin.

8.b.2. The long-range goal of the program is "to restore anadromous fish runs while at the same time protecting naturally producing resident fish, to allow for a balance of wild, native and hatchery fish populations" (GAIA, 1994;WDFW, 1994;WDFW,1996). The Cowlitz Falls Project Fish Collection Facility and SBC were designed and constructed as the cornerstone for a "trap and haul" operation that could successfully attract and collect a high percentage of

downstream migrants. The preliminary estimates of FGE indicated a high probability of success for attracting and collecting steelhead.

8.b.3. The successful use of guidance flow and strobe lights as an effective fish behavioral guidance tool for juvenile salmonids at the Cowlitz Falls Project would be directly applicable to regional juvenile fish passage programs. As is amply discussed and documented in regional salmonid reviews and recovery plans (NPPC, 1994; BPA, 1994; CRITFC, 1995; NMFS, 1995a, 1995b; OTA, 1995; NRC, 1996; ISG, 1996), the passage of juvenile salmonids downstream at dams is a major obstacle to population survival. The System Operation Review (BPA 1994, Appendix C-1, p. 4-25) notes that downstream juvenile survival is essentially the only measure that directly relates hydrosystem operation to relative health of salmonid populations, because this is the only life-cycle activity that plays itself out exclusively within the waters of the hydrosystem. Because juvenile salmonids above Bonneville Dam have no alternative to passing mainstem (and often tributary) dams in the Columbia River basin, all plans recognize the urgent obligation to develop safe passage mechanisms. At the Cowlitz Falls Project collection efficiency for migrating smolts is the key to success for the reintroduction program as the two reservoirs and dams below this project effectively block smolt passage downstream.

8.b.4. Passage through turbines is hazardous. The bulk of river flow is usually directed through turbines for generation of electricity. Because juvenile migrants are adapted to follow river flow, they are drawn through the turbines creating mortality rates ranging from 2 to 20 percent (Whitney et al., 1997). There are various causes for mortality in turbines and more "fish-friendly" turbine designs are under development (Cada et al., 1997). However, guidance of fish away from turbine intakes has been the most consistent engineering approach to promote safer fish passage (Mighetto and Ebel, 1995; OTA 1995). The most extensively deployed fish-guidance system in the Columbia-Snake mainstem is the submersible traveling screen in turbine intakes, which screens the upper layers of water entering the turbine intake and directs them to the gatewell and a transportation channel in the dam (Mighetto and Ebel, 1995). Such screens are expensive, they cause physical damage to many migrants (descaling is most common), and they counteract (rather than use) the natural migration tendencies of the fish. Thus, more cost-effective and less damaging methods are sought to guide fish to safer avenues of passage and/or collection systems. Again, any smolts that pass the Cowlitz Falls project through the turbines are lost to the reintroduction program.

8.b.5. Spill is recognized as a management tool that can provide a safer alternative migration route (CRITFC 1995; NMFS, 1995a). Because juvenile migrants are generally surface oriented, they preferentially follow large surface currents toward spillways rather than diving deep to follow turbine flows. However, spill during the smolt migration at the Cowlitz Falls Project is not desirable as any smolts that pass the project become land locked in Riffe lake and are lost to the reintroduction program.

8.b.6 Surface-flow bypass systems have recently been developed, which capitalize on the natural surface-migrating tendencies of juvenile salmonids but require less water than spill (Johnson et al., 1997). However, surface bypass systems have had difficulty in attracting and capturing juveniles with their small flows wherever the bypass is not directly above the main attracting turbine flow, as was the initial prototype hydrocombine at Wells Dam. Coutant (1998) noted that while we have tried to simulate natural river hydraulics to promote successful passage of adults upstream, we have not tried to simulate similar natural river hydraulics encountered by juveniles migrating to the ocean.

8.b.7. This project would test the hypothesis that guidance flow and strobe lights can provide an effective guidance behavioral tool for juvenile salmonids at the Cowlitz Falls Dam. More importantly, this project would demonstrate the feasibility of applying these tools to mainstem Columbia and Snake River dams. Successful testing at Cowlitz Falls is expected to lead to testing at other facilities and eventually at major mainstem projects such as at Lower Granite Dam (Corps of Engineers) and Wanapum Dam (Grant County PUD). Compared with mainstem dams on the Snake and Columbia rivers, the Cowlitz Falls Dam has a smaller and less complex forbay, but is still a scale that is transferable to other hydroprojects. Spring chinook, steelhead and coho are the species of concern throughout the basin, as well as in the Cowlitz Falls Reintroduction Program.

c. Relationships to other projects

8.c.1 Bonneville Power Administration owns all power generation through 2032 under a power purchase agreement with Lewis County PUD. The LCPUD operates this project until then under the direction of Bonneville Power Administration. It is unique in that the funds for the Cowlitz Falls Project Fish and Wildlife Program come out of BPA's Power Generation funds and are entirely separate from BPA's Fish and Wildlife Program. This project also falls under the NMFS ESA rules for the Lower Columbia River. NMFS currently has listed Cowlitz late winter steelhead as threatened, and are currently reviewing chinook and cutthroat. The Cowlitz Reintroduction Program is a component of the State's conservation initiative being prepared to meet NMFS recovery plan requirements.

8.c.2. Lewis County PUD provides assistance and maintenance for the reintroduction program and ongoing research. The PUD is responsible for all operations associated with the 200 ton crane and associated jib crane. The PUD installs the fish baffle panels, lowers fyke nets and controls all aspects associated with the use of the cranes and related maintenance. The Project Biologist (on loan from LCPUD to BPA) coordinates the ongoing reintroduction efforts between the PUD and WDFW as well as any other agencies requiring use at the Project.

d. Project history (for ongoing projects)

e. Proposal objectives:

8.e.1. 1. We propose to determine the efficacy of guidance flows and strobe lights as behavioral guidance tools to increase FCE and FGE for steelhead, coho and spring chinook smolts to the Cowlitz Falls Surface Collection Facility. We will test the hypothesis that guidance flows can provide effective cues to migrant smolts that increases guidance and entry into the SBC collection flumes and that strobe lights effectively reduce passage through the induction slot and enhance the opportunity for these fish to discover guidance flow cues and enter the SBC collection flumes. We propose to use radio telemetry, fyke and flume nets, and the SBC collection catches to test and evaluate the hypothesis. We will enumerate surface bypass collection catches for each on/off study block to measure increases in collection efficiency.

2. We will assess how environmental conditions effect strobe light efficiecy; ie diel patterns, turbidity and flow. If feasible turbidity and flow may be incorporated into the statistical analysis as covariates.

3. We will complete annual reports, quarterly updates and a final project completion report and identify effective ways to utilize this technology to enhance FGE and/or meet other fish guidance needs at other hydroprojects throughout the Columbia Basin. If successful we will

submit a proposal for fy2001 extend the testing of directed flow and strobe lights further into the forebay outside the "near zone" to increase guidance and collection efficiency.

f. Methods

Study Design:

8.f.1. The experimental design will consist of a randomized block design with on and off treatments. The design is consistent with an analysis of variance design. If appropriate, environmental conditions such as river flow and turbidity will be treated as covarients. Initial study design reviews suggest that 300 radio tags would provide an adequate sample size to measure and test the study hypotheses for steelhead smolts. In addition we propose to conduct two pilot studies with fifty coho and fifty chinook. A statistician experienced with fish passage studies and projects will guide final study design. The tests would be conducted over the duration of the migration period for each species beginning in early May for steelhead and continuing on through mid July or later for the age zero spring chinook smolts. Radio telemetry, flume netting and fish facility collections will provide the tools to measure and evaluate the efficacy of strobe lights and guidance flows. Criteria for success with the strobe lights would be significantly fewer numbers using the induction slot with strobe lights on. For guidance flows, success would be measured by significantly greater numbers or proportions of study fish entering the collection flume with guidance flows on than when off untagged or tagged fish using a bypass entrance with directed turbulent attraction flow when compared with the number using a bypass entrance without directed turbulent attraction flow.

Guidance Flows: Task #s 1.c., 1.d.

8.f.2. We propose to use a number of pumps to generate a series of jets of water that would mix with the surrounding water in a plume of turbulent eddies and serve to guide migrant smolts. The hydraulics of such plumes is well understood and generally consists of a high-velocity mixing zone near the nozzle followed by a slower-moving, three-dimensional sequence of vortices. The water jet creates both turbulence (which is believed to be a location cue for migrating fish) and momentum (which migrating fish are believed to seek as a way to minimize energy expenditure in downstream migration). Water jets would be directed toward the slot in the baffle panel and on into the entrance to the bypass/collection flumes at depths normally used by salmonids. The final water jet would direct the fish into the bypass flume. We hypothesize that the smolts will sense and follow this guidance flow rather than the flow nets present in the forebay that descend into the turbine intakes or lead away from the project. We plan to conduct some pilot work at the Cowlitz project in 1999 to test equipment and approaches to provide guidance flows that smolts will recognize and follow. This will help us refine our techniques for the study in 2000.

Telemetry Methods: Task #'s 1.c., 1.d., 1.e..

8.f.3. "Coded" radio transmitters produced by Lotek Engineering will be used to track the movements of juvenile steelhead, chinook salmon, and coho salmon. Releases will occur over the middle 80% of the spring out migration for steelhead, chinook salmon, and coho salmon. The release strategy will be designed to populate the forebay with sufficient numbers of tagged fish to provide a continuous population in the forebay of tagged fish among untagged fish expected to move through the project during each test condition. Tagging related mortality will probably

range between 1% and 3%. Mortality rates from previous studies conducted at Lower Granite Dam was about 3% in 1996 and less than 1% in 1997 (Adams,1998).

8.f.4. Coded tags offer several features which make them ideal for studying juvenile fish movements at Cowlitz Falls Dam. Because each tag is uniquely coded, as many as 100 tags can be broadcast on the same frequency without losing the ability to identify distinct individuals. As a result, the scan cycle of the receiver is relatively short and the probability of not detecting a fish is fairly low. Additionally, a Digital Spectrum Processor (DSP) can be used in conjunction with a receiver to scan multiple frequencies and codes simultaneously. The DSP eliminates any need for a scan cycle and allows for instantaneous detection of all fish within range of the antennas. A disadvantage of the DSP, however, is that excess electrical noise from the dam can interfere with the detection of valid signals from radio-tagged fish. Electrical interference underwater is not a significant problem, so DSP technology will be used extensively in underwater applications. During 1997 at Lower Granite Dam we successfully installed a DSP system in an aerial application immediately downstream of the spillway. We propose to use DSP technology at Cowlitz Falls in other aerial applications if the level of ambient electrical noise is low.

8.f.5. The proposed antenna array at Cowlitz Falls Dam will consist of about 25 aerial antennas and 50 underwater antennas. The antennas will be linked to about 14 automated data collecting receivers used in conjunction with 7 DSPs and will provide continuous information on fish movements at the dam. Aerial arrays will be located both upstream and downstream from the dam, around the collection facility raceways, on the downstream face of the dam, on the upstream face of the dam, and along the debris barrier. The underwater antenna arrays will be located on the debris barrier, on the fyke net frame in the draft tubes, around the vertical slot surface collection area, in the induction channel, in front of the spillbays, and on and around the strobe lights.

Fish Collection: Task #'s 1.d.

8.f.6. The number and species of fish captured at the Cowlitz Falls Fish Facility can be accurately enumerated for each treatment period with very little mortality by operating the facility as designed (overall facility mortality for 1998 was less than .05%). Catch nets can also be set in the surface collection flumes to monitor the number and species entering each of the four surface bypass collection entrances to provide additional data as needed.

g. Facilities and equipment

8.g.1. The Cowlitz Falls Project Fish Collection Facility was designed and constructed as the cornerstone for the upper Cowlitz River Reintroduction Program. The facilities were completed in 1996 and are considered to be state of the art. The facilities include: baffle panels, fish flap gates, a flume transport system, juvenile and adult separation, PIT tag detection system, work-up areas and holding facilities for juveniles and adult fish. In addition, the Cowlitz Falls Dam provides a 200 ton crane and jib crane (capable of moving and installing baffle panels, fyke nets etc.). The facilities in place are adequate to perform the proposed program.

8.g.2. This proposal budgets for, six (6) tri packs consisting a total of eighteen (18) 901 Flash Heads to be installed in the induction slots of one turbine. We propose to purchase the AGL 4100 Aquatic Guidance Lighting System, produced by FTCA. This system is specifically designed for underwater usage as a behavioral barrier for fish.

h. Budget

8.h.1 The budget will allow WDFW and cooperators to complete the project tasks. Funding for sallaries covers the costs for on-site field work required for study tasks, basic compiling and summary of the in-season test data and up to one month time for the project biologists. The WDFW on-site project biologist will oversee, supervise and coordinate day to day activities for this study. The BPA on-site representitive will also provide staff support to assist with some of the study tasks. These activities are not included in the budget. Travel costs cover the expenses incurred by USGS staff involved with on-site task specific work at the project. Equipment costs represent a significant component of the total and include strobe lights for one turbine (two induction slots), radio tags, telemetry equipment, pumps and accessories to provide the guidence flows. WDFW is seeking additional funding from Tacoma Public Utilities through the FERC relicensing process to help with the equipment costs.

Section 9. Key personnel

The key project staff for this proposal merge a collective scope of experience and skills to successfully complete thsi project. Key study personnel include: Charles Morrill, WDFW - lead project coordinator/manager,Mike Kohn, on loan to BPA from LCPUD - co-project coordinator/manager, Dennis Rondorf, BRD, USGS - lead investigator with radio telemetry, John Serl, WDFW - lead on-site field biologist, and Ron Brown, Flash Technology - Technical advisor for Strobe lights and technology.

Ron Brown, Director of Marketing

Flash Technology Corporation America

Vendor of the Strobe Lighting Behavioral Barrier System

Flash Technology Corporation of America is a privately held corporation which is headquartered in a suburb of Nashville, Tennessee. Having been in business for over 27 years, Flash Technology is recognized as the world's leading manufacturer of strobe aviation obstruction lighting and airport runway lighting. The corporation is international in scope, presently conducting business in over 40 countries . Our account base includes many major corporations and governmental agencies, to include NASA, for whom we designed and built the landing lights for the Space Shuttle Program (these landing lights can be seen at a distance of 90 miles above the earth). In 1993, Flash Technology introduced the AGL 901 Aquatic Guidance flashhead . This strobe lighting unit was the first flashhead specifically designed for underwater usage as a behavioral barrier for fish . In 1995, Flash Technology introduced the AGL 4100 Aquatic Guidance Lighting System . This system is multi-functional, highly flexible, remotely controlled, providing real time responses to site specific variables. A portable computer allows the operator to monitor the system and make real time adjustments to flash rates, intensity levels, the sequence of flashing lights, and the sequential flash rate . For large projects, the power center and computer systems are assembled into trailers at our plant and driven to the project site, thereby , avoiding costly on site set up.

Ron Brown received a Bachelor of Arts degree from the University of Kentucky, and a Masters of International Business Management from The American Graduate School of International Management, Glendale, Arizona . With over 20 years of marketing managerial experience in new technology introduction and holding five United States patents, Ron joined Flash Technology in 1993 as the Director of Marketing. During this period of time his primary responsibility has been dedicated to the scientific research and development of the usage of strobe lighting as a cost effective behavioral barrier for fish. In 1995, Flash Technology and Great Northern Paper entered into a five year testing agreement to evaluate the capability of an AGL 4100 Strobe Lighting System to enhance the direction of downstream migrating smolts toward the surface bypass inlets at the client's Weldon Dam, located in northern Maine on the Penobscot River . This successful application continues. Other projects have included working directly with the U.S. Army Corps of Engineers , Bureau of Reclamation , Washington Department of Fish & Wildlife , Idaho Department of Fish & Game , and the U. S. Fish & Wildlife Service . By invitation, Ron has published and made presentations on the usage of strobe lighting as a behavioral barrier for fish to the Electric Power Research Institute's Fish Passage Workshop and the American Fisheries Society 1997 Annual Meeting.

MICHAEL S. KOHN

Lewis Co PUD biologist on loan to BPA

QUALIFICATIONS

Experience coordinating with multiagency technical committees involving

the anadromous fish reintroduction in the upper Cowlitz River and previously on fish passage issues in the Yakima Basin. Responsibilities include chairing the Cowlitz Falls Technical Advisory Committee and overseeing research and monitoring programs.

Experience performing a variety of activities for the Bonneville Power Administration, including: facility design review, permitting, budget development and review, as well as participating in many biological studies. Responsibilities also include informing county officials, sportsmen groups, landowners and the general public regarding the various fish and wildlife programs.

Experience overseeing the design, implementation, maintenance and monitoring of the Cowlitz Falls Wildlife Mitigation Plan. Previously a member of the Fish and Wildlife Committee overseeing the implementation of the Wildlife Plan and currently a member of the Habitat Evaluation Procedure (HEP) team responsible for evaluating the project habitat baseline.

Experience monitoring and evaluating the various life stages and migrations of anadromous fish. Experience includes training and supervising entry level biologist and up to 12 fisheries technicians. Responsibilities included managing large quantities of data, data analysis and report writing.

EDUCATION

BS General Science, Portland State University; 1982. Major course work in Biology and Geography.

Previously attended Hope College in Holland Michigan. Major course work in Biology.

Work Experience

Feb 1993 -Present Lewis County PUD (hired in cooperation with BPA)

Aug. 1987 -Feb. 1993 Yakima Indian Nation - Fisheries Resource Management, Toppenish, WA. Supervisor at the Chandler Juvenile Fish Facility in Prosser (smolt monitoring and evaluation). Previously the Project Leader the final year of the Spring Chinook Enhancement Project. Field Supervisor for spawning surveys in Methow and Okanogan Basins for three seasons.

Charles Morrill, Fish Biologist, Washington State Department of Fish and Wildlife

Education:

M.S. in Fisheries, University of Idaho, 1972

B.S. in Wildlife Management, University of Maine, 1969

Current Employment and Responsibilities:

Mr Morrill has over 20 years of professional experience working with Anadromous Salmonids in Washington for the Washington Departments of Fisheries, Wildlife, and now Fish and Wildlife. Since the early 1980's he has worked on and led a variety of projects within the Columbia Basin including Coded-Wire tag recovery programs, Smolt Monitoring Programs at Lower Monumental and Lower Granite Dam, and for the last three years, the Fish Passage/Facility component of the Cowlitz Falls Anadromous Fish Reintroduction Program.

Currently Mr. Morrill:

Leads and supervises WDFW work at the Cowlitz Falls Fish Facility as part of the Cowlitz Falls Anadromous Fish Reintroduction Program

Supervises WDFW Smolt Monitoring work at Lower Granite Dam (LGR) under the Northwest Power Planning Councils Fish and Wildlife Water Budge Measures Program under the oversight of the Fish Passage Center (FPC).

Supervises WDFW work at Lower Granite Dam as part of the Corps Walla Walla District annual Juvenile Fish Facility Operation Program.

Represents the agency as a technical member on the PIT Tag Steering Committee (PTSC), serves as a co-chair, provides technical direction and guidance for the continued development and use of PIT tags and the PIT tag data base (PTAGIS) within the Columbia Basin. The PTSC is a standing subcommittee under the Fish Passage Advisory Commission (FPAC) and Columbia Fish and Wildlife Authority (CBFWA). The Pacific States Marine Fisheries Commission's (PSMFC) Pit Tag Operations Center (PTOC) handles the day to day management and system operation for system hardware and software.

Represents the agency as technical Co-chair of the PIT Tag Transition Team that is overseeing BPA's project to replace the current 400 KHz PIT Tag system in the Columbia River Basin with a new standard ISO system in time for the year 2000 smolt migration.

Verhey P.,Morrill C., Witalis S. and Ross D. 1997 Lower Granite Dam Smolt Monitoring Program. Annual Report. Washington State Department of Fish and Wildlife. DRAFT. Prepared for United States Department of Energy. Bonneville Power Administration. Division of Fish and Wildlife. Project Number 87-127. Contract Number 88-FC38906.

Verhey P., Morrill C. and Ross D. 1996 Lower Granite Dam Smolt Monitoring Program. Annual Report. Washington State Department of Fish and Wildlife. Prepared for United States Department of Energy. Bonneville Power Administration. Division of Fish and Wildlife. Project Number 87-127. Contract Number 88-FC38906. 26 pages

Verhey P., Morrill C. and Goffredo T. 1995 Lower Granite Dam Smolt Monitoring Program. Annual Report. Washington State Department of Fish and Wildlife. DRAFT. Prepared for United States Department of Energy. Bonneville Power Administration. Division of Fish and Wildlife. Project Number 87-127. Contract Number 88-FC38906.

Verhey P., Morrill C., Goffredo T. and Ross D. 1994 Lower Granite Dam Smolt Monitoring Program. Annual Report. Washington State Department of Fish and Wildlife. Prepared for United States Department of Energy. Bonneville Power Administration. Division of Fish and Wildlife. Project Number 87-127.. Contract Number 88-FC38906. 40 pages

Verhey P., Morrill C. and Kuras J. 1993 Lower Granite Dam Smolt Monitoring Program. Annual Report. Washington State Department of Fish and Wildlife. Prepared for United States Department of Energy. Bonneville Power Administration. Division of Fish and Wildlife. Project Number 87-127. Contract Number 88

Dennis W. Rondorf, Fishery Research Biologist

Education:

M.S. Oceanography and Limnology, University of Wisconsin, Madison, 1981

B.S. Wildlife Management, University of Minnesota, St. Paul, 1972

Current Employment and Responsibilities::

D.W. Rondorf serves as a Fishery Research Biologist and Section Leader for the Anadromous Fish Ecology section at the Columbia River Research Laboratory, Biological Resources Division, U.S. Geological Survey, Cook, Washington. Current areas of research include the behavior and ecology of Snake River wild and hathery fall chinook salmon, the distribution of smolts and relation to gas supersaturation in the main stem Columbia River, and behavior of smolts to evaluate a prototype surface collector at Lower Granite Dam, Washington. In recent years, D.W. Rondorf has lead research teams using radio telemetry, geographic information systems (GIS), global positioning systems (GPS), remotely operated underwater vehicles (ROV),

hydroacoustic fish stock assessment systems, and acoustic Doppler current profilers (ADCP) as research tools. Between 1979 and 1997, D.W. Rondorf was employed by the research division of the U.S. Fish and Wildlife Service and the National Biological Service to conduct research on juvenile salmon in the Columbia River basin.

Adams, N.S., D.W. Rondorf, S.D. Evans, J.E. Kelley, and R.W. Perry. 1998. Effects of surgically and gastrically implanted radio transmitters on swimming performance and predator avoidance of juvenile chinook salmon. (*In Press*) Canadian Journal of Fisheries and Aquatic Sciences.

Adams, N.S., D.W. Rondorf, S.D. Evans, and J. E. Kelley. 1998. Effects of surgically and gastrically implanted radio transmitters on growth and feeding behavior of juvenile chinook salmon. Transactions of the American Fisheries Society 127:128-136.

Parsley, M.J., D.W. Rondorf, and M.E. Hanks. 1998. Remote sensing of fish and their habitats. Proceedings of instream and environmental flows symposium-technology and policy issues. (*In Press*) North American Lake Management Society and others, Denver, Colorado.

Adams, N.S., D.W. Rondorf, E.E. Kofoot, M.J. Banach, and M.A. Tuell. 1997. Migrational characteristics of juvenile chinook salmon and steelhead in the forebay of Lower Granite Dam relative to the 1996 surface bypass collector tests. U. S. Army Corps of Engineers, Walla Walla, Washington.

John David Serl

On Site Cowitz Falls Fish Facility Lead Biologist

EDUCATION

University of Washington, Seattle, Wa. Master of Science in Fisheries, Spring 1998 (Expected).

University of Washington, Seattle, Wa. Bachelor of Science in Fisheries, *cum laude*, June 1991.

EMPLOYMENT

FISH BIOLOGIST II, April 1996-Present.

Cowlitz Falls Anadromous Fish Reintroduction project, Washinton Department of Fish andWildlife, Randle, Washington

- Assisted with final construction and start up of the Cowlitz Falls Fish Facility.
- Evaluated Fish collection efficiency of the Facility.
- Supervised, trained and directed a crew of 3 to 13 technicians.
- Provided on-site direction for capture, marking, identification and transportation of juvenile salmonids at the fish collection facility and Lake Merwin trap.
- Provided coordination for project activities between Contractors, PUD, consultants and WDFW groups.

_ Collected, entered and summarized project data.

_ Assisted in preparation of reports, memos, letters and budgets.

RESEARCH ASSISTANT, September 1992-June 1995.

Washington Cooperative Fish and Wildlife Research Unit, University of Washington, Seattle, Wa.

_ Designed a study of the effects of urbanization on stream fishes within a watershed.

_ Sampled fish populations and habitat use by electrofishing.

_ Determined trout ages from collected scales.

_ Analyzed collected data via personal computer.

_ Produced a written thesis.

FISH AND WILDLIFE HELPER, March 1992-September 1992.

Public Utility District No.1 of Chelan County, Wenatchee, Washington.

_ Assisted with studies of juvenile salmonid passage at hydro-electric projects.

_ Monitored numbers and condition of downstream migrating juvenile salmon.

_ Participated in wildlife habitat improvement projects.

Section 10. Information/technology transfer

Products. The results of the experiments would be published as agency annual reports and summarized in the peer-reviewed literature, if suitable. If the system is successful, there would be on-site demonstrations for interested personnel of governmental agencies and other organizations.

Congratulations!